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ABSTRACT

With limits on both personnel and time available to conduct effective instruction, the decision is being made increasingly to enhance instructor-led courses with Computer-Based Training (CBT). The effectiveness of this conversion is often unknown and in many cases empirical evaluations are never conducted. This paper describes and discusses the evaluation and effectiveness of adaptive courseware authoring and utilization in the context of the Submarine Officer Basic Course (SOBC) at the Naval Submarine School, Groton, CT. The Naval Submarine School (NAVSUBSCOL), the "Center of Excellence" for Submarine Warfare Training, has recently dedicated a new, state-of-the-art electronic training facility that hosts ten Advanced Electronic Classrooms (AEC), a building-wide enterprise Classified LAN (CLAN), and external high bandwidth connectivity. The benefits of implementing adaptive CBT in the Submarine School range from possible time savings in specific curricula to automated remediation and instruction. Manpower savings will permit Submarine School to pursue implementation of a Distance Learning support division comprised of experienced subject matter experts who have instructional expertise in front of a class and as CBT authors. CBT cannot replace the instructor completely. Students asserted uniformly that the face-to-face communications were at times critical for the understanding of particularly complex concepts. Training via CBT provides exceptional flexibility to both the schoolhouse (in terms of resource scheduling) and to the student (to learn at his convenience). (Author)

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# An Empirical Evaluation of Sonar Courseware Developed with Intelligent Tutoring Software (*InTrain*™) at Naval Submarine School

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**Abstract:** With limits on both personnel and time available to conduct effective instruction, the decision is being made increasingly to enhance instructor-led courses with Computer-Based Training (CBT). The effectiveness of this conversion is often unknown and in many cases empirical evaluations are never conducted. This paper describes and discusses the evaluation and effectiveness of adaptive courseware authoring and utilization in the context of the Submarine Officer Basic Course (SOBC) at the Naval Submarine School, Groton, CT.

## Introduction

The Naval Submarine School (NAVSUBSCOL), the "Center of Excellence" for Submarine Warfare Training, has recently dedicated a new, state-of-the-art electronic training facility that hosts ten Advanced Electronic Classrooms (AEC), a building-wide enterprise Classified LAN (CLAN), and external high bandwidth connectivity. The NAVSUBSCOL Officer Training Department provides the Fleet with Prospective Commanding Officers (PCOs), Prospective Executive Officers (PXOs), Department Heads, Division Officers, and a host of officer billet and specialty training courses. NAVSUBSCOL training responsibilities range from engineering, damage control, and ship control, to combat training simulation and tactical employment of the submarine. Currently, the curricula are based primarily on instructor-led presentations and practical exercises in lab/simulator environments.

Recently, NAVSUBSCOL determined that the demand for training was outpacing the available resources (instructor-led presentations and practical exercises). To address the situation, NAVSUBSCOL searched for a supplement to the instructor-led training by adding computer-based training (CBT). The goal was to leverage the available resources of the lead instructors while incorporating additional benefits of current courseware, maintaining internal control of content, and reduce staff loading.

This case study discusses the efforts made at NAVSUBSCOL to integrate CBT into the curriculum and the effects this type of learning will have on learning outcomes. Through a comparison study of both CBT and instructor-led courseware, supportive evidence can be garnered that support a savings in development time and improvements in test scores.

Traditional multimedia instruction creates an engaging learning environment in which multiple sensory pathways convey information to the student. NAVSUBSCOL wanted to choose an authoring tool that would allow instructors to re-use content and learning objectives throughout multiple courses, while

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delivering individualized instruction to a large volume of students. Likewise, it wanted the authoring tool to be easy to use and require low developmental times due to constant turnover of personnel.

*InTrain*™ provides such a tool. *InTrain* instruction builds and tailors the content and form of instruction to the moment-to-moment needs of the student. This results in faster acquisition and longer retention than is seen with conventional learning approaches.

In a marked contrast to conventional CBT, *InTrain* develops an individual education plan (IEP) for each student and makes its instructional decisions at run-time. Students proceed when they demonstrate that they are meeting the goals of instruction mastery. Students who need more time or different methods to reach the same level of performance receive the instruction they need.

While forming an IEP, *InTrain* considers information about the student (*e.g.*, the student's mastery profile and instructional history) and about the goals of the curriculum (*i.e.*, which objectives must the student meet at what level of proficiency). The IEP describes the order in which the system will introduce new topics and the training techniques that will support the introduction. When assessment is needed (both pre- and post-tests may be used), *InTrain* randomly selects among the assessment options (*e.g.*, test questions) associated with the learning objectives under investigation. Similarly, when *InTrain* wants to present instruction, it selects among the instructional options associated with the target learning objectives. Instruction and assessment continue until the student has adequately mastered all of the required learning objectives.

Shorter development times are also addressed by the *InTrain Author*! software (*InTrain Author*! is the interface through which *InTrain* courseware is authored. *InTrain* does not require any programming experience and offers an "as you go" tutorial on content development. This ease of use allows for shorter development time and less "training" time for new courseware development.

## Method

To assess the effectiveness of the training to be demonstrated, Sonalysts, Inc. conducted a study in conjunction with NAVSUBSCOL. Traditional instructor-led classroom students were given 8.5 hours of instruction about SONAR, as were the CBT students. The learning objectives and goals of the content presented to each group was the same. In contrast, another group of students received *InTrain* instruction. Both groups were given the same amount of time to interact with the content.

After the second group completed the curriculum, both groups were then given a final written examination, comprising of 80 questions. Instructors scored the tests that included multiple-choice and true/false questions. The students needed to achieve a minimum of 70% to pass the course. The scores of the instructor-led group, were in-line with historical, satisfactory averages for this content and type of instruction.

Traditionally, training for the NAVSUBSCOL has taken place in instructor-led classrooms. Each classroom comprises approximately 24 students, who spend a portion of a 10-week course learning passive sonar theory and underwater acoustics. The focus of the comparison is on a specific 8.5 hours of the Sonar curriculum taught during the ten-week course. The 8.5 hours of instruction cover the following courses: Passive Sonar Equation, Total Background Noise, Beamforming, Figure of Merit, Source Level, and Propagation Loss.

While each course has a standardized set of Learning Objectives and a Curriculum Outline, each is modified accordingly. Courseware for traditional instruction has usually been developed in PowerPoint lessons with Instructor Discussion Points and Lessons Learned being conveyed by each instructor. PowerPoint are inherited by the previous lesson instructor and amended when the need occurs.

Students are scheduled for each of the above topics based on numbers of students, classroom availability, and instructor availability. Delivery time for each course is a pre-defined amount and scheduled by a central person. Students are assigned to the next course as they move through the curriculum. At the end of each component of instruction (sonar, tactics, plots, etc.) students are given a test comprising 80 questions.

In contrast to traditional methods, CBT was developed. To address NAVSUBSCOL's goal of authoring CBT "in house," Submarine School staff instructors, working with guidance from instructional designers and subject matter experts from Sonalysts, utilized *InTrain AUTHOR*! to develop an eight-hour, adaptive CBT course on the passive sonar theory equation, theories, and underwater acoustics. This development effort was a multi-stage process. Initially instructors were given a basic INTRO courses in

courseware development and creating computer-based training. Instruction focused on creating and decomposing learning objectives, creating assessment items, and developing content (at a variety of targeted levels). Ultimately, one instructor became responsible for development of 8.5 hours of SONAR courses. *InTrain* allows for instructional method neutrality. The tool does not require one to build/create Sharable Content Objects/presentations in a particular manner, thereby allowing the developer complete freedom in content presentation and delivery. Sonalysts served as "consultants" to the instructor in charge of development. Media was reused from courseware previously authored for other topics, instructor-led training, and Submarine Officer On-Board Training (SOBT) courses.

The content developed using *InTrain*, was delivered to a class of 21 students that utilized the courseware during two four-hour dedicated periods, plus a one-hour wrap-up following the testing. The courseware was parsed into six topics that mimicked the training methodology of the material in instructor-led instruction. The CBT was deployed using options that permitted the student to learn the material and demonstrate mastery through assessment. Students were permitted two attempts at the assessments. If the student failed a second assessment, an instructor-led remediation was conducted.

Students were given the same amount of time to learn using the computer-based course as they were given to learn through the traditional methods. The reasons for this were two-fold: 1) Delivery of CBT was an emerging concept within NAVSUBSCOL. While computer-based training is available, the courses are self-paced auxiliary learning on Lessons Learned and Practice for defined skills. There was no model from which to build time/scheduling differences around this type of learning. 2) The SOAC/SOBC Associate Assistant Director of Officer Training maintained that it was important that an appropriate amount of time was scheduled for students to receive the training. The most efficient manner to achieve this was to "schedule" it in the same blocks of time as the traditional methods of delivery.

Upon completion of the material, students were able to review/return to the material at their convenience for follow-on study.

There were four measures by which results were garnered for this comparison study: Survey, Test, Historical Averages, and Development Time.

*Survey* – At the conclusion of the computer-based instruction (*InTrain Author!*), students and instructors were given a Level 1 evaluation. This survey consisted of both open-ended questions and Likert-scale questions.

*Test* – The paper-based test included 80 questions that were both multiple-choice and true/false. Both groups of students (CBT and instructor-led) were given the same test and graded using the same set of instructors.

*Historical Averages* – The historical averages used in the study are the averages of students who had gone through the instructor-led training in the past two years. The scores were from a slightly revised version of the test given to these students (The revision included the learning objectives but a few questions were changed).

*Development Time* – Development time for the *InTrain* course was measured.

## Results

The results of both courseware development and actual "testing" of the courseware as indicated below show improved in results in both the authoring content and the student performance.

## Survey

The results of the students' survey were interesting. A 5-point Likert scale was used for the 20 questions.

The areas that scored highest (4–4.5) were the presentation of the material and the way in which students interacted with the course. A score of 4.2 was given to the overall usefulness of the course within the curriculum in general.

The students' response to another set of questions (scoring 2.6–2.9) demonstrated that no additional instruction or assessment was necessary, lending credibility to the individualized component of the training which provides "just enough" instruction to achieve mastery of the learning objective. There were enough assessment and instruction to teach the topic without being overwhelmed by obscure

materials. This method targets the learner to specific information to support specific concepts and objectives.

## Test Results

Students' scores in both the instructor-led group and the *InTrain* group were measured and compared on the basis of results from the 80-question test.

| | Instructor-Led Group (Last 2 classes of students) | *InTrain* Students (One class) | Historical[1] (Instructor-Led Group) |
|---|---|---|---|
| **Population** | 75 | 21 | > 300 |
| **Student Mean[2]** | 88.5% | 95% | 84.5% |
| **No. of Exam Failures[3]** | 3 | 0 | N/A |

**Table 1. Evaluation Results**

## Courseware Development

No metrics exist to gauge the amount of development time required to prepare instructor-led courseware because the instructor-led materials are inherited from the original instructor and revised over several years.

Although CBT development ratios can vary widely, actual development time was compared to a benchmark of 200 hours per hour of CBT. For this effort, that would yield an approximate effort of 1600 hours of authoring time to design, storyboard, implement, and test the course.

In contrast to this benchwork, the Submarine School staff spent a total of 500 hours for the development effort. Sonalysts' instructional designers and subject matter experts spent an additional 150 hours providing feedback and guidance on effective CBT design and content presentation.

## Discussion

The survey results yielded some interesting information. The open-ended questions asked throughout the survey indicated that the students were favorably impressed with and receptive to the CBT that was presented. Additionally, they liked the "individualized instruction" that was presented through *InTrain* allowing some of the students to finish quicker and more efficiently than others who required more time or instructor intervention. Some negative responses about the CBT included the need to have an instructor review session at the conclusion of training (before the test). Another negative comment was the length of time dedicated to each training session (taught via CBT) was too long. In both cases each comment can be resolved in a simple and effective manner.

NAVEDTRA 131 (Task Based Instruction), the controlling doctrine for the course in quesiton, requires that all instruction that results in a *bottleneck* be serially scheduled. That means, for a class of 12 students participating in a learning experience that takes 4 hours and has capacity for only 6 students, an entire training day must be scheduled against it. By its nature, CBT provides unparalleled flexibility to obviate bottleneck scheduling. Students learn at their own pace, on their own schedule. In an instant example, the other six students not in the learning experience can complete assigned CBT required for another part of the course. The time saved by removing bottleneck scheduling is approximately 24 hours.

If given proper integration into the NAVSUBSCOL curriculum scheduling process, students would proceed through the courses on an individualized basis. In fact, they would be assigned courses and

a completion date and proceed at their own pace toward that completion date. This is the way that NAVSUBSCOL is moving with the integration of a Learning Management System (LMS) to create such assignments.

More CBT is undergoing development in other areas of the 10-week curriculum matrix. When more of the courses are converted to CBT and an entire curriculum can address scheduling, changes will be easier to implement. When timesaving is realized, an instructor-led review session can be addressed and implemented to quantify knowledge gained through the CBT.

Additionally, the study yielded anecdotal evidence that four hour training periods for the students were too long and resulted in student "burn-out," an assertion supported by student feedback following the training. A consensus of input suggests that a period of two hours at any given time/topic is the longest that should be scheduled. The artificiality introduced by the beta test (i.e., the test dictated two four-hour periods of study) required the student not study when they were ready to, but rather when the test required it. As such, student mastery and navigation through the material suffered at the end of the first training period due to student fatigue.

Finally, we address test scores. We can see that the scores on the test were higher for the *InTrain* classes than the traditional instructor-led method. Since both groups were achieving at a high-level, the observed results might actually understate the size or effect one would expect in other settings. Another factor that influenced the "ceiling effect" introduced by these scores is the high average among the students. If the tests were longer and students had been scoring in the 70%, we would have expected to see an even greater range of effectiveness defined.

## CBT Benefits

The CBT in question does provide some benefits when measuring interaction time metrics: In the study, the students required an average of 8.2 hours to complete the 6 topics in the CBT. In comparison, instructors require 8.5 hours to teach the same material in an instructor-led lecture format. One would assume that the CBT seat time would be reduced about 50-60%. However, given the restrictions of the imposed time schedule this was not seen. One would assume that the deployment time would be less once a new scheduling system is implemented and appropriate time values are added to the scheduling matrix to accommodate Computer-Based Courses.

Additionally, there was a time-savings in terms of instructor remediation time. A total of 7 students required remediation by an instructor, yielding a total of approximately 1.5 man-hours of instructor time for student instruction (vice the nominal 8.5 hours required to teach the material *plus* any time spent in individual tutoring). For the beta test, Submarine School instructors attended all training sessions, but it is envisioned that once CBT is well entrenched in the SOBC curriculum and students understand how to use it, direct instructor supervision will not be required. Rather, CBT will be employed to teach basic theory and concepts, and instructor led seminars synthesizing material and covering more advanced concepts will be used to periodically ensure students have satisfactorily advanced through the material.

On its face, the integration of Sonalysts' tool represents a 59.3% savings in development time over a typical CBT effort. However, some elements in the study influence this apparent savings:

- The Topic Learning Objectives derived from course Personal Performance Profiles (PPP) tables already existed; hence the course was not built "from scratch."
- The Submarine School staff author had no training in CBT development. While this is a *de rigueur* requirement for any authoring tool fielded for Submarine School, it is also true that those same personnel will become more proficient in the use of the tool as more CBT is authored.
- A limited amount of media (3 graphics) was produced in support of this effort. For the remaining approximately 700 graphics and animations used, existing media and or local generation tools were leveraged for the media production. It is anticipated that during a typical CBT authoring effort, the existing media bank will not be quite as well populated.
- The purpose of the study was also to test *InTrain AUTHOR!* Several software problems were identified and corrected during the test. This resulted in an aggregate reduction in authoring capability for a period of about one week. *InTrain* has completed Beta testing and made changes, so this type of delay should no longer occur.

## Conclusions

The entire authoring effort, deployment of the course, and post-CBT analysis spanned 3.5 months. Sonalysts, provided the IT, instructional design, and subject matter expertise in an effort to investigate the usefulness of *InTrain* CBT in an established, structured U.S. Navy curriculum. Submarine School provided exceptional dedication to the effort, including the combined work of the CBT author and testing team.

The *InTrain* CBT test provided valuable input to the product developers at Sonalysts, both in terms of performance and study recommendations. As part of the implementation of distance learning efforts at NAVSUBSCOL, Sonalysts will be involved with the integration of the submarine officer training curricula into the THINQ™ LMS (Training Server). This initial testing allowed the software engineering staff at Sonalysts to evaluate the requirements and use patterns of CBT (and specifically *InTrain*) in an enterprise LAN environment.

As part of the population of the LMS with content, Submarine School must develop and deploy a robust web-hosted CBT course structure to allow remote users access to training prerequisites and remediation to support both professional development and continuing training onboard submarines. This test provided the Submarine School staff some experience in CBT design and provided some metrics and recommendations about implementing CBT to maximize its benefits to the student population.

## Summary

Based on student performance and feedback received, the following conclusions can be drawn from the test:

- The benefits of implementing adaptive CBT in the Submarine School range from possible timesavings in specific curricula to automated remediation and instruction. Manpower savings will permit Submarine School to pursue implementation of a Distance Learning support division comprised of experienced subject matter experts who have instructional expertise in front of a class and as CBT authors.
- CBT cannot replace the instructor completely. Students asserted uniformly that the face-to-face communications were at times critical for the understanding of particularly complex concepts. While not applicable to the material delivery in the Beta test, NAVSUBSCOL is planning on maintaining some instructor-led seminars to provide higher-level synthesis of read material.
- Training via CBT provides exceptional flexibility to both the schoolhouse (in terms of resource scheduling) and to the student (to learn at his convenience).

The potential to improve training efficiencies, effectiveness, and achieve Fleet readiness improvements with the infusion of advanced training methodology and technology is enormous and clearly measurable. This effort is not envisioned to replace the resident training experience but to enhance the level of professional development that can be achieved and to provide continuous training and maintenance of readiness to students and groups ashore or at sea. A substantial commitment to investing in information technology infrastructure has been made, but the return on investment will not be realized without a concomitant fielding of advanced learning methodology products. It is recognized that this vision in its many forms and variations cannot be achieved immediately; the first small steps will reflect changes in technology and processes.

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[1] Historical averages are based on exam results from the last year.

[2] The written examination included two topics that were not developed into CBT but were presented to the students in traditional lecture format. The average for those two questions was 79%. A corrected average for performance on just the InTrain instructed material was 96.2%. Removal of these two topics from the other tests did not change the historical or last 4 class means in any significant fashion (± 0.2%).

[3] Exam failures are counted in the student mean as 70%. Remediation and re-exam are conducted upon exam failure.

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